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(54) ELECTRIC TONG WITH ONBOARD HYDRAULIC POWER UNIT

(71) Applicant: **Weatherford Technology Holdings, LLC**, Houston, TX (US)

(72) Inventors: **Frank Wern**, Hannover (DE); **Bjoern Thiemann**, Burgwedel (DE); **Thomas Kotschy**, Burgdorf (DE); **Michael Wiedecke**, Salzhemmendorf (DE)

(73) Assignee: **Weatherford Technology Holdings, LLC**, Houston, TX (US)

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E21B 19/16 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 19/164*** (2013.01); ***E21B 19/163*** (2013.01)

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(Continued)

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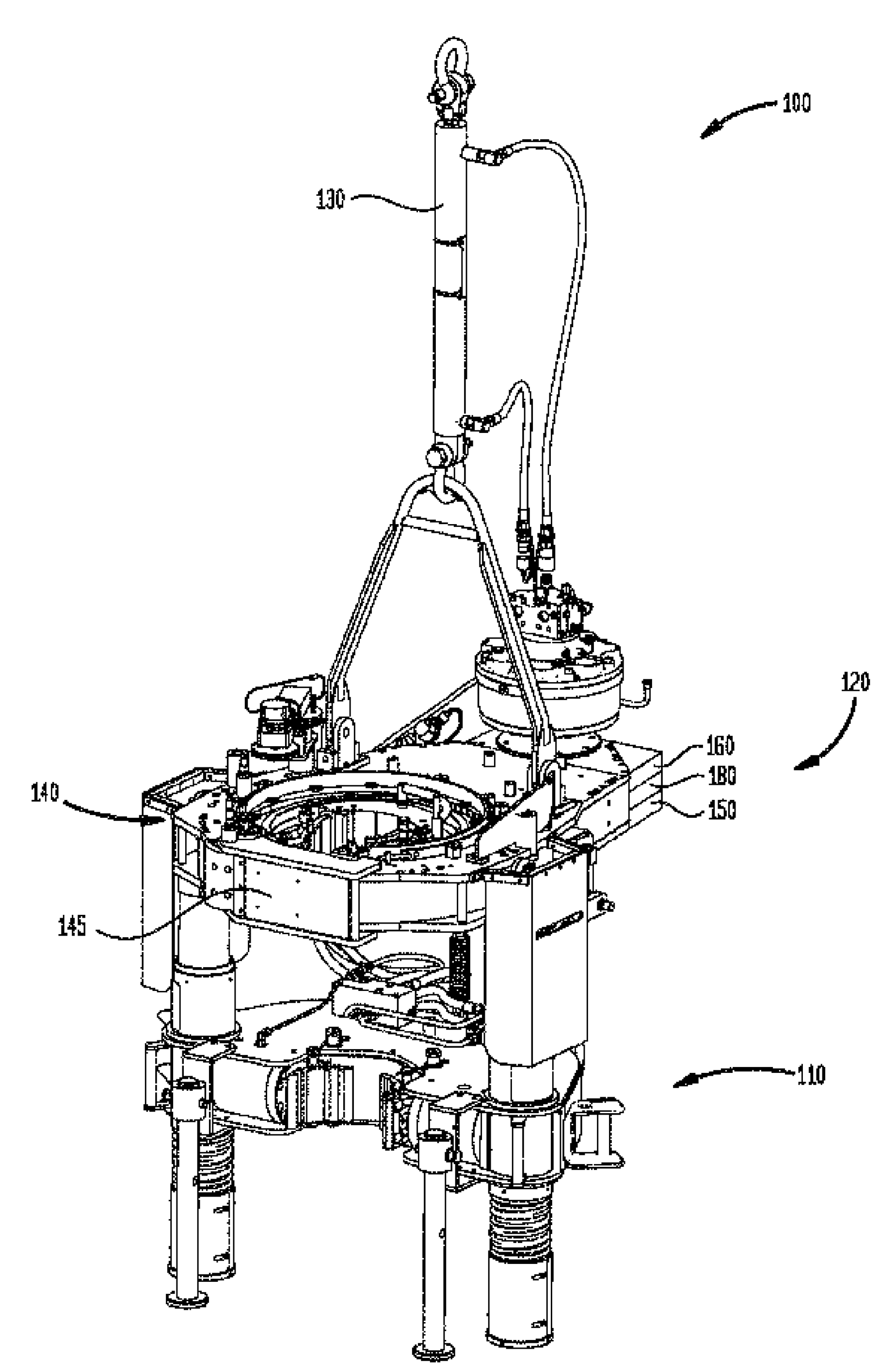
(74) *Attorney, Agent, or Firm* — Smith IP Services, P.C.

(57) **ABSTRACT**

A method and apparatus for local hydraulic power generation on an electric tong, including a power tong for spinning tubulars; a first electric motor functionally connected to the power tong; a plurality of hydraulic power consumers including a backup tong for clamping a tubular string; a second electric motor functionally connected to the plurality of hydraulic power consumers; electronics to drive the first electric motor and the second electric motor; and a switch-box providing at least two configurations of the system. A method includes arranging a tong system in a hydraulic power configuration; supplying hydraulic power with an onboard electric motor to at least one of a plurality of hydraulic power consumers to position a tubular for make-up; arranging the tong system in a rotary drive configuration; supplying at least one of torque and rotation with the onboard electric motor to a power tong.

13 Claims, 6 Drawing Sheets



(58) **Field of Classification Search**
USPC 81/57.14
See application file for complete search history.

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FIG. 1

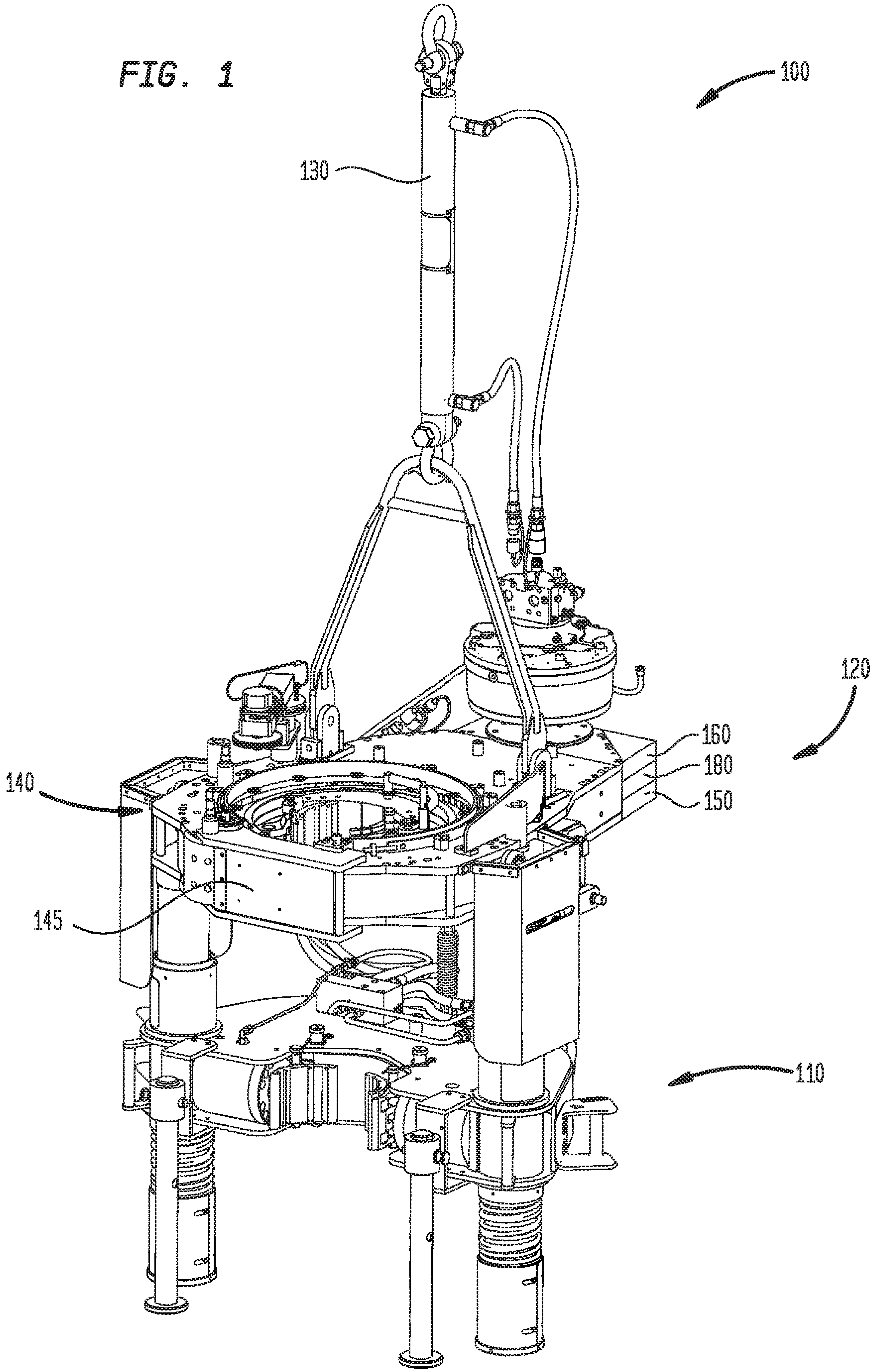


FIG. 2

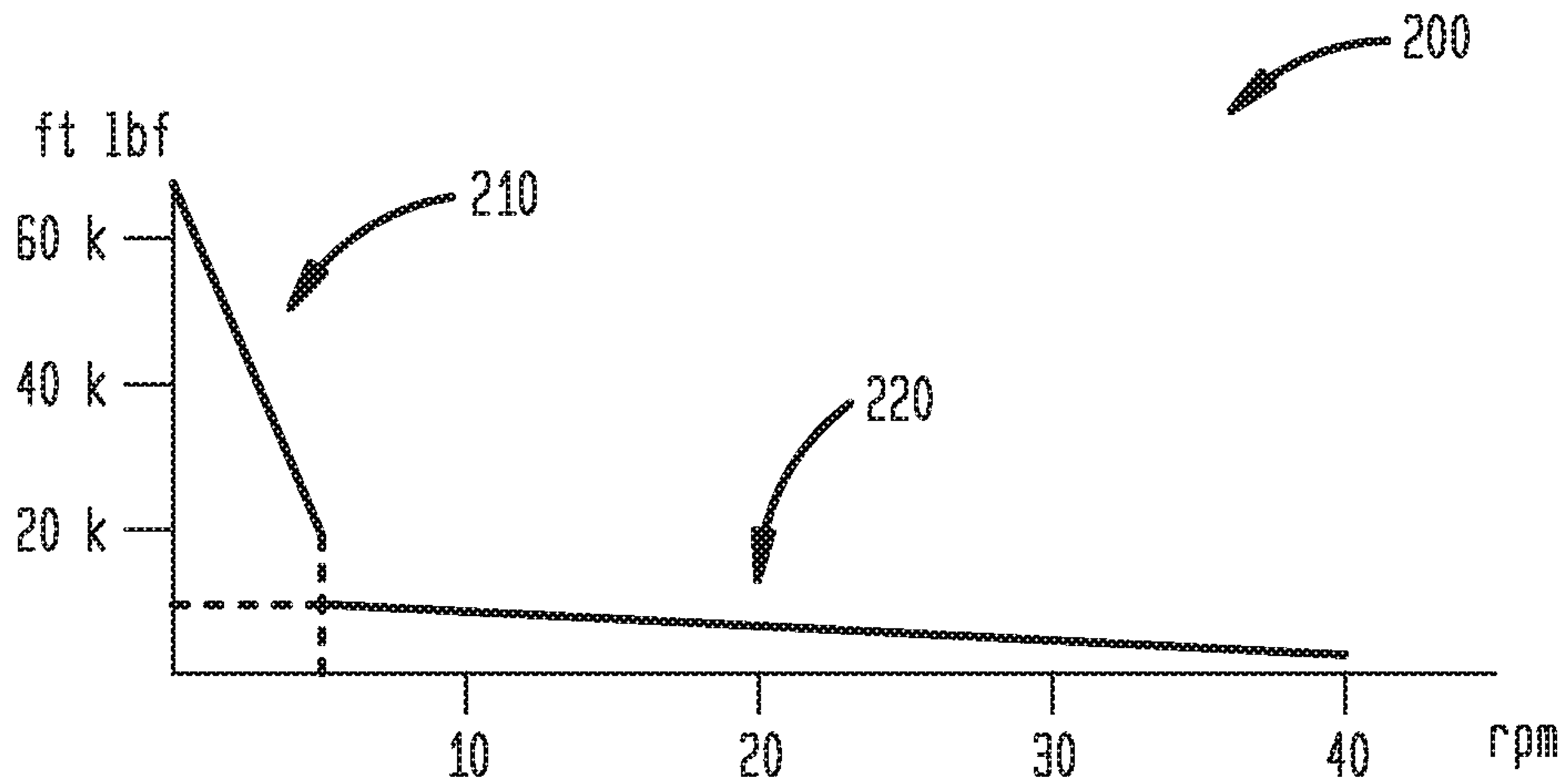
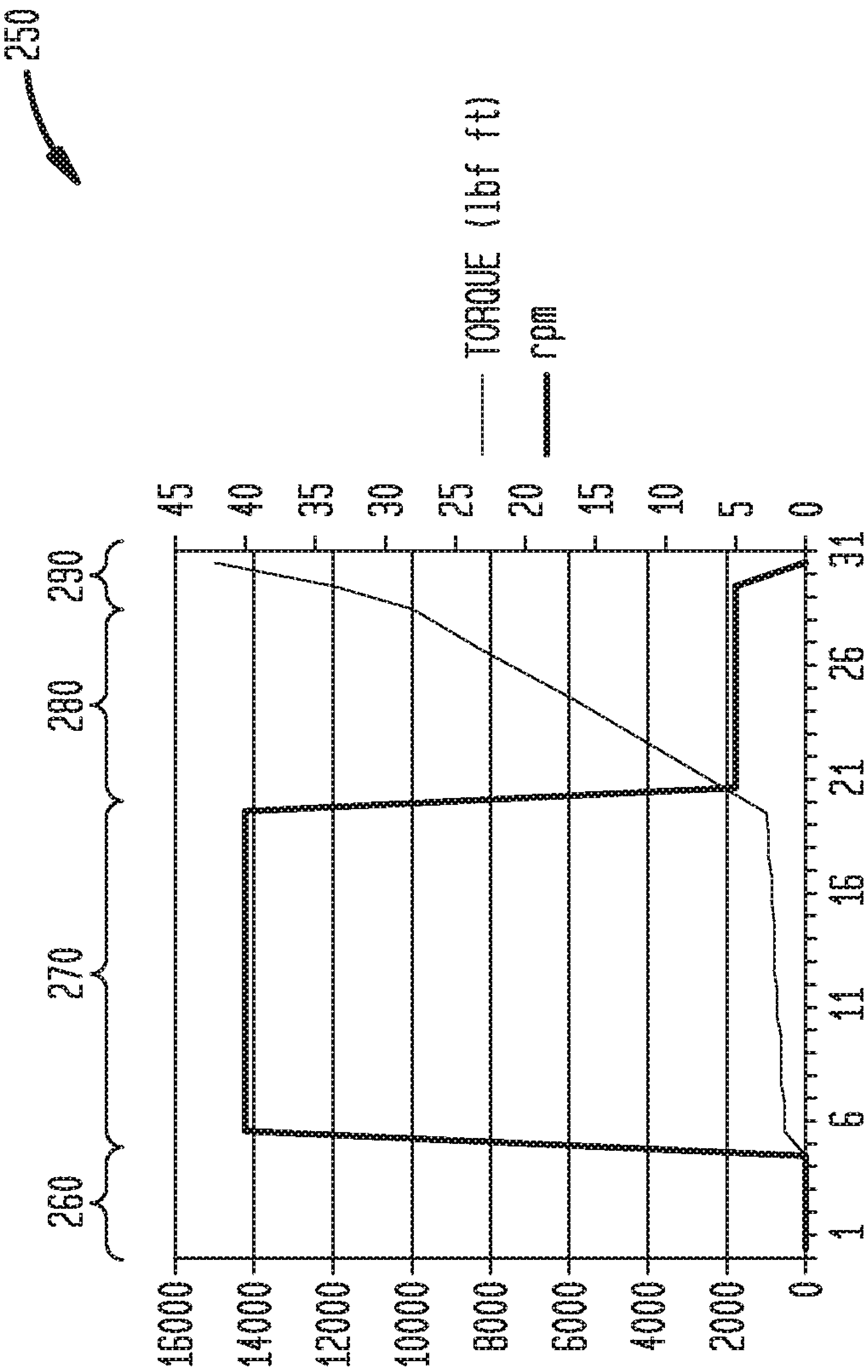


FIG. 3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260
270
280
290
TORQUE (lbf ft)
rpm
16000
14000
12000
10000
8000
6000
4000
2000
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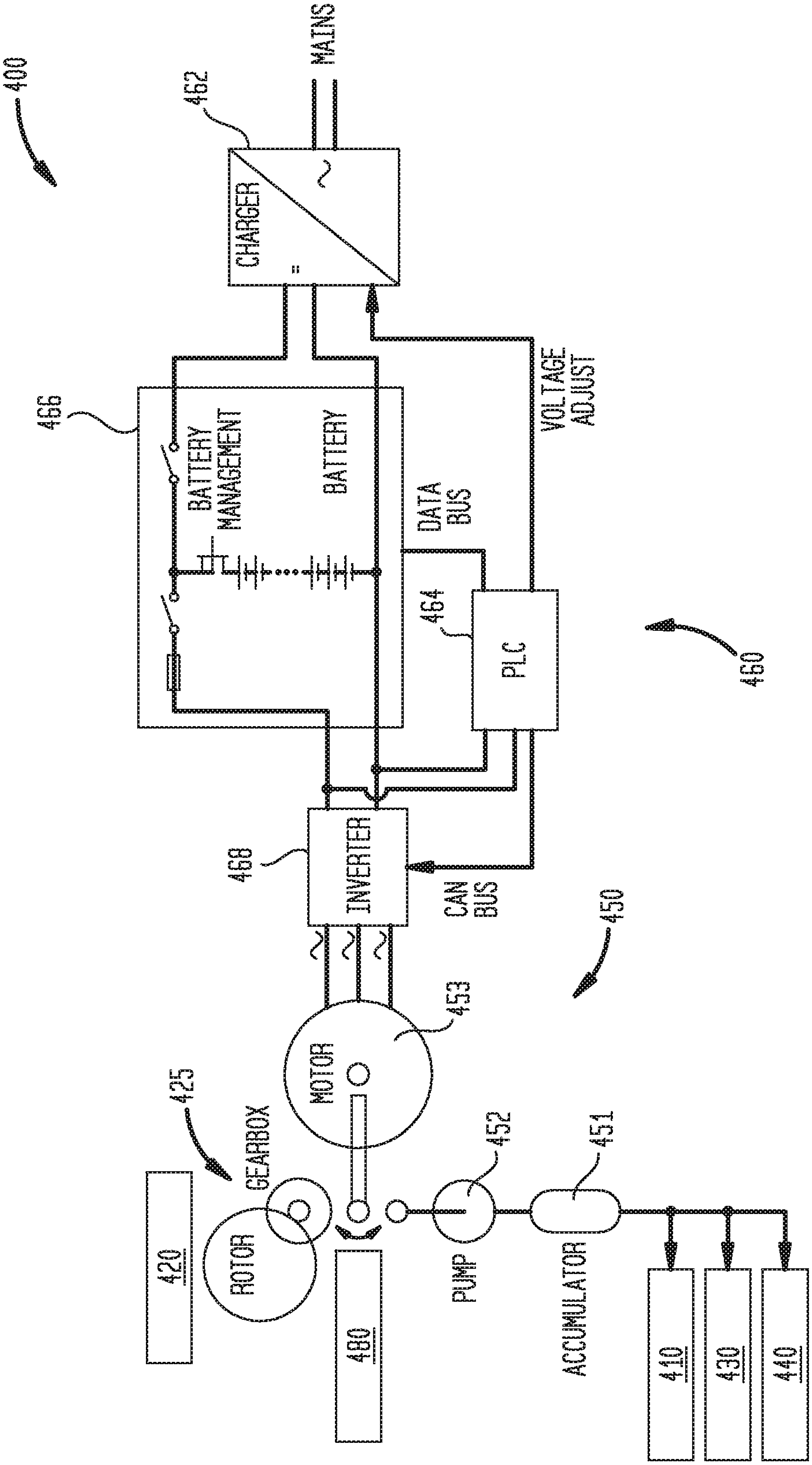
30
25
20
15
10
5
0
1
6
11
16
21
26
31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462
CHARGER
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BATTERY
DATA BUS
VOLTAGE ADJUST
464
PLC
460
468
INVERTER
CAN BUS
450
453
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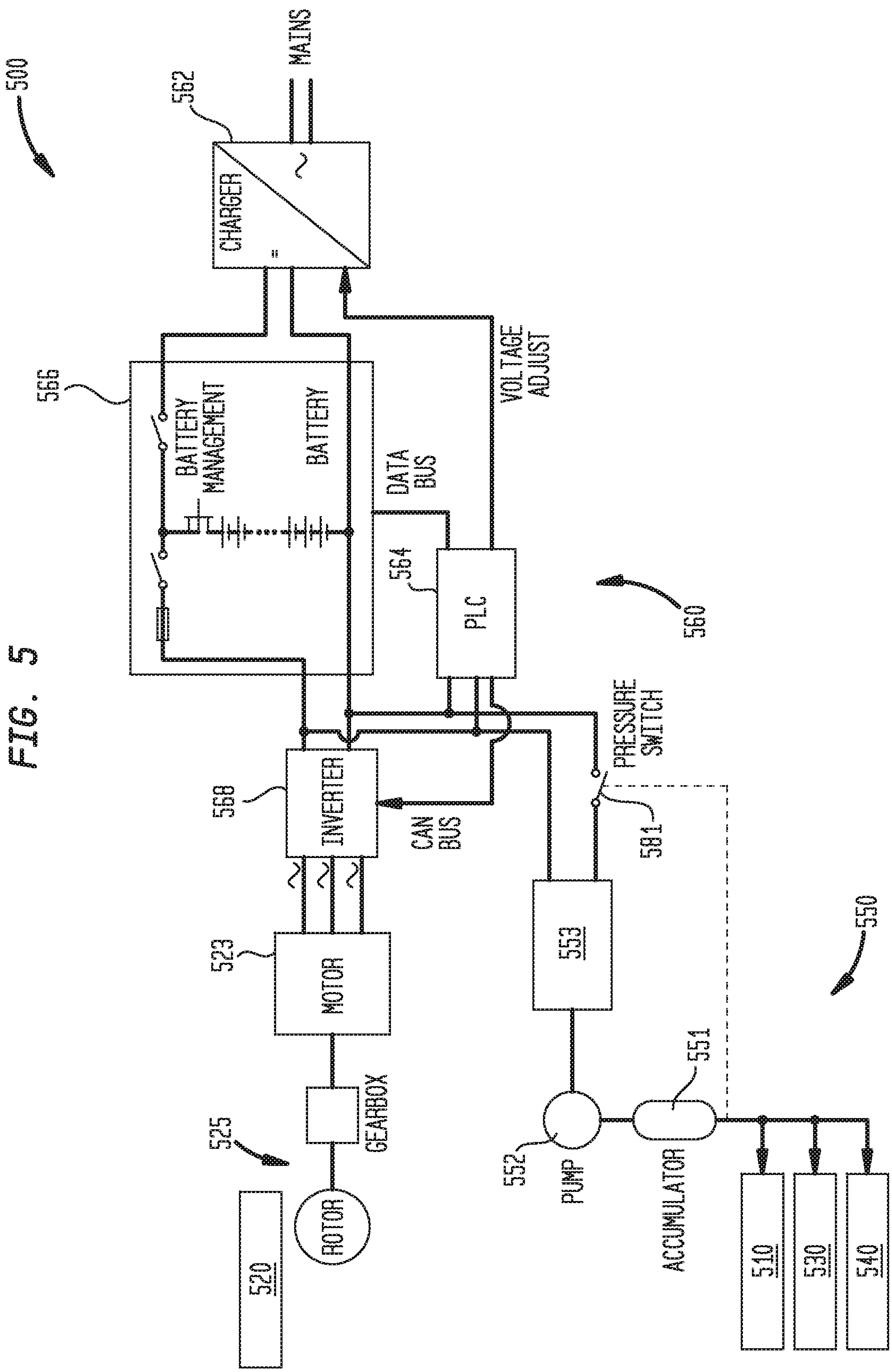
425
GEARBOX
ROTOR
420
480
PUMP
452
ACCUMULATOR
451
410
430
440

FIG. 4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SWITCH
568
INVERTER
CAN
BUS
581
553
550
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ROTOR
520
551
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ACCUMULATOR
510
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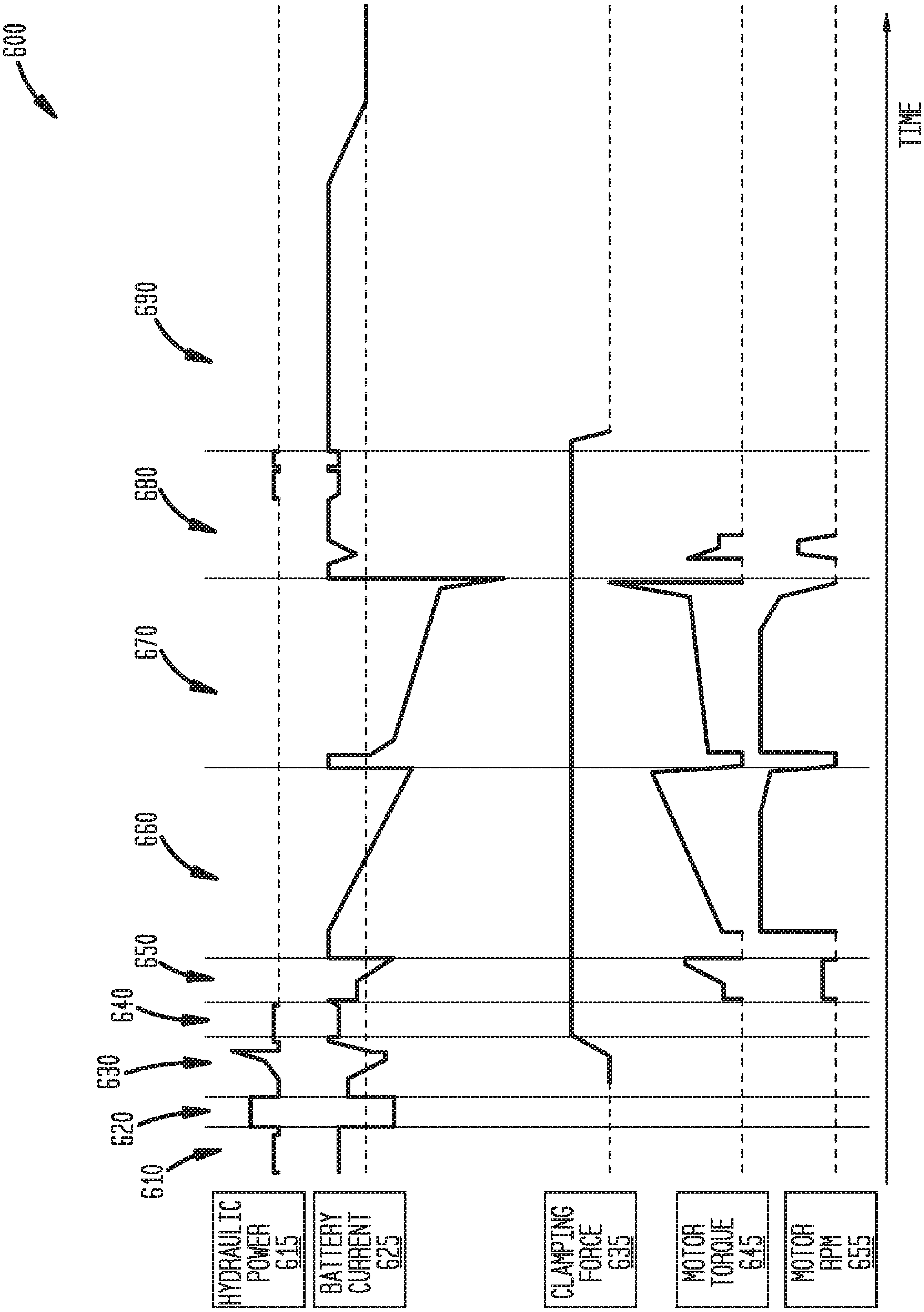
540

FIG. 5

FIG. 6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610
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650
660
670
680
690
HYDRAULIC POWER 615
BATTERY CURRENT 625
CLAMPING FORCE 635
MOTOR TORQUE 645
MOTOR RPM 655
TIME

ELECTRIC TONG WITH ONBOARD HYDRAULIC POWER UNIT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation of application Ser. No. 15/675,404 filed on Aug. 11, 2017, which application is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

Embodiments of the present invention generally relate to systems and methods for local hydraulic power generation on an electric tong.

Description of the Related Art

Tongs are devices used on oil and gas rigs for gripping, clamping, spinning, and/or rotating tubular members, such as casing, drill pipe, drill collars, and coiled tubing (herein referred to collectively as tubulars and/or tubular strings). Tongs may be used to make-up or break-out threaded joints between tubulars. Tongs typically resemble large wrenches, and may sometime be referred to as power tongs, torque wrenches, spinning wrenches, and/or iron roughnecks. Tongs have typically used hydraulic power to provide sufficiently high torque to make-up or break-out threaded joints between tubulars. Such hydraulic tongs have suffered from the requirement of a hydraulic power generator on the rig floor, necessitating big hydraulic hoses connecting the hydraulic power generator to the tong, causing contamination concerns and excessive noise. Moreover, due to the distance from the power generator to the tong, hydraulic tongs have suffered from reliability issues and imprecise control of the torque.

Electric tongs have been proposed. For example, U.S. Pat. No. 9,453,377 suggests retrofitting a conventional hydraulic power tong with an electric motor. The electric motor would then be used to operate the power tong for rotating or spinning a tubular during make-up or break-out operations. A separate electric motor is proposed to actuate lift cylinders between the power tong and the backup tong. Another separate electric motor is proposed for applying clamping force to the backup tong. However, electric power supply for a tong might be insufficient when extreme forces are required. Moreover, the multiplicity of electric motors may be impractical when costs are an issue.

Local hydraulic power generation on an electric tong may provide improved handling, greater reliability, and increased safety and efficiency at reasonable costs.

SUMMARY OF THE INVENTION

The present invention generally relates to systems and methods for local hydraulic power generation on an electric tong.

In an embodiment a tong system includes a power tong for spinning tubulars; a first electric motor functionally connected to the power tong; a plurality of hydraulic power consumers including a backup tong for clamping a tubular string; a second electric motor functionally connected to the plurality of hydraulic power consumers; and electronics to drive the first electric motor and the second electric motor.

In an embodiment, a tong system includes a power tong for spinning tubulars; a plurality of hydraulic power consumers including a backup tong for clamping a tubular string; an onboard electric motor; and a switchbox providing at least two configurations of the tong system: in a first configuration, the onboard electric motor drives the power tong but does not supply hydraulic power to the plurality of hydraulic power consumers; and in a second configuration, the onboard electric motor does not drive the power tong but does supply hydraulic power to at least one of the plurality of hydraulic power consumers.

In an embodiment, a tong system includes a backup tong for clamping a tubular string; an onboard electric motor; and an onboard hydraulic power unit coupled to the onboard electric motor to supply hydraulic power to the backup tong.

In an embodiment, a method of making-up tubulars includes arranging a tong system in a hydraulic power configuration; supplying hydraulic power to at least one of a plurality of hydraulic power consumers to position a tubular for make-up; arranging the tong system in a rotary drive configuration; supplying at least one of torque and rotation to a power tong; wherein an onboard electric motor of the tong system supplies the hydraulic power when the tong system is in the hydraulic power configuration, and the onboard electric motor supplies the at least one of torque and rotation when the tong system is in the rotary drive configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

FIG. **1** illustrates a tong system with local hydraulic power generation.

FIG. **2** illustrates a graph of maximum torque values vs. rotation speed for a power tong in low gear and in high gear.

FIG. **3** illustrates a graph of torque and rotation speed required over a typical work make-up cycle for a power tong.

FIG. **4** illustrates a tong system that is configured to switch electric power between a rotary drive configuration and a hydraulic power configuration.

FIG. **5** illustrates a tong system that is configured to provide dedicated electric power to a rotary drive subsystem and a hydraulic power subsystem.

FIG. **6** illustrates an exemplary make-up cycle for a tong system with local hydraulic power generation.

DETAILED DESCRIPTION

Embodiments of the present invention generally relate to systems and methods for local hydraulic power generation on an electric tong.

In some embodiments, onboard electric motors may be beneficially utilized to supply large power densities that are controllable with a variable frequency drive. For example, the speed and/or torque of an electric motor may be controlled to reach a predefined target torque and/or to keep a predefined torque profile. The torque of the electric motor may be proportional to the current that is regulated electronically by a variable frequency drive, while the speed may be in phase with the generated frequency. In one embodiment, miniaturized, controllable electric motors may be mounted on the tong system (i.e., "onboard"). In some embodiments, the onboard electric motors may be capable of producing output in the range of about 2 kW/kg to about 5 kW/kg. In some embodiments, the onboard electric motors may be between about 8 kg and about 12 kg, for example, about 10 kg. In some embodiments, the onboard electric motor may be coupled to one or more of a reducing gear, another gear stage for low gear, and a flameproof housing. In some embodiments, these combined components may be between about 64 kg and about 96 kg, which may still be lighter than similar power provide by a hydraulic system.

As illustrated in FIG. **1**, a tong system **100** suitable for use on oil and gas rigs generally includes a backup tong **110** for gripping and/or clamping the tubular string and a power tong **120** for spinning the tubular. The backup tong **110** may generally be below the power tong **120**. The backup tong **110** clamps the tubular string to provide an opposing force to the torque applied to the tubular from power tong **120**. Consequently, the backup tong **110** may be characterized as generally having high torque at low rpm requirements. The power tong **120** spins the tubular during make-up/break-out operations. Consequently, the power tong **120** may be characterized as generally having high torque at high rpm requirements. The tong system **100** may also include one or more lift actuators **130** (e.g., a linear actuator cylinder) for vertically positioning the backup tong **110**. The tong system **100** may also include one or more door actuators **140** for controlling the tubular access door **145**. In embodiments discussed below, tong system **100** also includes one or more of a hydraulic power unit **150**, power electronics **160**, and/or a switchbox **180**, to provide local hydraulic power generation.

In some embodiments, the average power required to operate a power tong **120** during one work cycle may be less than 10% of the maximum power. For example, FIG. **2** illustrates a graph **200** of the maximum torque values vs. rotation speed for a 50 k ft lbf power tong **120** in low gear and in high gear. It should be appreciated that the power of the tong may be limited by the available power of the hydraulic supply and by physical layout. In the example of FIG. **2**, the rated pressure (that results in the maximum torque) may be about 200 bar, and the maximum volume flow rate the tong may accept may be about 100 liter/minute. Therefore, the maximum power that the system may be capable of would be about 33.33 kW. As illustrated in FIG. **2**, the power tong **120** may operate in low gear at region **210**, generating torque of between about 20 k ft lbf and about 60 k ft lbf. With the power tong **120** in low gear, the tubular rotates at up to about 5 rpm. Therefore, the maximum power requirement in low gear is about:

$$20\text{ k ft lbf}*0.305\text{ m/ft}*4.448\text{ N/lbf}*5\text{ rpm}*2*\pi/60\text{ s}=14.2\text{ kW} \quad (1)$$

The power tong **120** may operate in high gear at region **220**, generating torque of between about 4 k ft lbf and about 10 k ft lbf. Therefore, the maximum power requirement in high gear is about:

$$3\text{ k ft lbf}*0.305\text{ m/ft}*4.448\text{ N/lbf}*40\text{ rpm}*2*\pi/60\text{ s}=17.0\text{ kW} \quad (2)$$

Likewise, when operating in the high gear region **220**, the power tong **120** may provide higher torque at lower rpm with similar maximum power requirements:

$$12\text{ k ft lbf}*0.305\text{ m/ft}*4.448\text{ N/lbf}*10\text{ rpm}*2*\pi/60\text{ s}=17.0\text{ kW} \quad (3)$$

The examples from Equations 1-3 are upper values which are normally only demanded for a short period of time. During an entire make-up cycle of about 120 seconds, the average power is about 10% of the maximum power requirement. Therefore, with the maximum power required in low gear region **210** or in high gear region **220** being approximately 14.2 kW and 17.0 kW respectively, the average power required in either of these regions is 1.4 kW and 1.7 kW, respectively, which is less than about 10% of the maximum power of the system (33.33 kW), and a local battery may be capable of supplying the power for the power tong **120** without significantly increasing safety concerns (e.g., risks of excessive heat in the explosive atmosphere of an oil rig). For example, peak power may be supplied to power tong **120** by a lithium titanate or lithium iron phosphate battery. Such a battery may supply about 1.2 kW/kg to about 2.4 kW/kg without excessive heating.

FIG. **3** illustrates a graph **250** of the torque and rotation speed required over a typical make-up cycle for a power tong **120**. At the beginning of the make-up cycle, in region **260** (e.g., about first 5 seconds), the rotor may be slowly rotated in low gear to engage the tubular threads and confirm that the threading has engaged correctly. During the middle of the make-up cycle, in region **270**, the rotor (now in high gear) speeds-up to the maximum speed (for example, as defined for this tubular type by the drilling contractor). The high rpm may be maintained for about 15 seconds until a reference torque is reached. For example, the reference torque may be selected to stop the tong well before the tubular shoulders engage. When the reference shoulder torque is reached, the power tong **120** is switched back to low gear. In region **280**, the make-up may be done smoothly and/or continuously in low gear (e.g. for about the next 8 seconds). Lastly, the threads are secured in region **290** as indicated by rapidly increasing torque and decreasing rpm. The required power, which is the product of torque and turns, is normally less than half of the maximum power. Furthermore, the complete work cycle is more than 2 minutes, because bringing in another pipe, stabbing- in, and finally lowering the string into the well takes most of the time. Considering this, the average power is about 10% of the maximum power of the tong.

Electric power supply for a tong might be insufficient when extreme forces are required. Moreover, the multiplicity of electric motors may be impractical when costs are an issue. Therefore, a source of local hydraulic power is proposed. As illustrated in FIG. **1**, tong system **100** includes local hydraulic power generation. As previously discussed, the tong system **100** includes a backup tong **110**, a power tong **120**, and one or more lift actuators **130**. Tong system **100** also includes a hydraulic power unit **150**. In some embodiments, hydraulic power for the backup tong **110** may be supplied by the hydraulic power unit **150**. For example, the backup tong **110** may utilize high force to clamp cylinders to clamp the tubular string and thereby counterbalance the high torque of the power tong **120**. In some embodiments, hydraulic power for the lift actuators **130** may be supplied by the hydraulic power unit **150**. For example, the lift actuators **130** may utilize high force to vertically position (e.g., raise or lower) the backup tong **110** while it clamps the tubular string. In some embodiments, the volume of the hydraulic power unit **150** may be less than (e.g., about 10% of) that of conventional hydraulic power units which had been located proximate the rig floor. For example, a rig floor hydraulic power unit that is capable of producing up to about 35 kW-about 40 kW may have a volume of about 400 liters, while hydraulic power unit **150** may have a volume of between about 30 liters and about 40 liters, or in some embodiments less than about 50 liters. Hydraulic power unit **150** may include a tank with a submerged motor and a dual stage pump. Hydraulic power unit **150** may include a tank with a submerged motor and a pump with a booster. Hydraulic power unit **150** may include a tank with a submerged motor with a variable frequency drive. Hydraulic power unit **150** may include a tank with a submerged small motor with a hydraulic accumulator. In some embodiments, the hydraulic power unit **150** may supply power so that the cylinders (e.g., clamp cylinders of backup tong **110**, lift cylinders of lift actuators **130**) have fast action while having maximum pressure. Exemplary hydraulic power units **150** may include compact hydraulic power packs wherein the motor shaft of the electric motor also acts as the pump shaft.

In some embodiments, the hydraulic power unit may be powered by an onboard electric motor. This may allow for a single electric motor to be utilized both for the power tong and for backup tong. For example, a switchbox may decouple the rotor of the power tong when the hydraulic pump is activated. FIG. **4** illustrates a tong system **400** that can switch between a rotary drive configuration and a hydraulic power configuration. As illustrated, tong system **400** includes a hydraulic power unit **450** that includes an accumulator **451** and a pump **452** (which may include a reservoir tank (not shown)). Tong system **400** also includes an onboard electric motor **453**. An exemplary onboard electric motor **453** may be a low voltage motor with integrated electronics. Hydraulic power unit **450** may supply hydraulic power to one or more hydraulic power consumers, such as the backup tong **410**, the lift actuators **430**, and the door actuators **440**. Onboard electric motor **453** may also and/or alternatively supply torque and/or rotation to power tong **420**. For example, switchbox **480** may switch the output of onboard electric motor **453** between the pump **452** and drivetrain **425** (e.g., a gearbox and a rotor) for power tong **420**. In some embodiments, switchbox **480** may be configured to switch the output of onboard electric motor **453** to pump **452** to store hydraulic power in accumulator **451** while one or more of the power tong **420**, backup tong **410**, lift actuators **430**, and/or door actuators **440** are inactive. In some embodiments, switchbox **480** may be configured to switch the output of onboard electric motor **453** to pump **452** to directly drive one or more of the backup tong **410**, lift actuators **430**, and/or door actuators **440**. In some embodiments, tong system **400** may not receive hydraulic power from an external source (e.g., a hydraulic power unit on the rig floor). Specifically, backup tong **410** may only receive hydraulic power from local hydraulic power unit **450**.

In some embodiments, onboard electric motor **453** may be selected to supply either (a) sufficient torque and rotation to power tong **420**, as illustrated by the work cycle graphs of FIGS. **2**-**3**, or (b) sufficient power to drive hydraulic power unit **450** between power tong work cycles, but not both at the same time, and no more than the maximum of the two. For example a DYNAX 60i motor includes integrated electronics while still being only about 14 kg. Consequently, onboard electric motor **453** may be small enough to not pose excessive risks (e.g., heat, noise, fuel consumption) in the rig environment.

Tong system **400** of FIG. **4** may also include electronics **460**. The electronics **460** may include a charger **462**, a programmable logic controller **464**, a battery **466**, and an inverter **468**. Electronics **460** and/or inverter **468** may function as a variable frequency drive for onboard electric motor **453**. Battery **466** may be a lithium iron phosphate battery and/or a lithium titanate battery. An exemplary battery **466** may be a 14 Ah Prismatic Pouch Cell, available from A123 Systems of Livonia, MI. The battery may be, for example, between about 5 kg to 10 kg. The battery **466** may be contained in a flameproof housing. It is believed that no ATEX standard currently exists for batteries on tong systems, and further testing may be needed. Onboard electric motor **453** may be driven and/or controlled by electronics **460**. For example, the torque of onboard electric motor **453** may be proportional to the current coming from the inverter **468**. Likewise, the speed of onboard electric motor **453** may be in phase with the frequency of the current coming from the inverter **468**. Onboard electric motor **453** may supply torque to power tong **420** in order to make-up to tubulars to a precise target torque while maintaining this torque for some time.

In some embodiments, onboard electric motor **453** and/or electronics **460** may be enclosed in a flameproof housing. For example, the flameproof housing may meet ATEX standards for class 1, zone 1, division 1. In some embodiments, the flameproof housing may be aluminum. In some embodiments, onboard electric motor **453** may be integrated with one or more components of electronics **460**.

In some embodiments, programmable logic controller **464** may switch power supply to the consumers. For example, the battery **466** may alternatively charge and discharge, the onboard electric motor **453** may switch between the drivetrain **425** and the hydraulic power unit **450**, and the sources of hydraulic power may be the pump **452** and/or the accumulator **451**. At times during operations, each of backup tong **410**, lift actuators **430**, and door actuators **440** may be powered by one or more of the sources of hydraulic power. The programmable logic controller **464** may determine which power source supplies which consumer at any point in time during operations.

In some embodiments, the hydraulic power unit may be powered by a dedicated onboard electric motor. This may allow for a dedicated electric motor to be utilized for the power tong and a smaller, dedicated electric motor to be utilized for the hydraulic power unit. FIG. **5** illustrates a tong system **500** with separate, dedicated electric motors for the rotary drive configuration and the hydraulic power configuration. As illustrated, tong system **500** includes a hydraulic power unit **550** that includes an accumulator **551** and a pump **552** (which may include a reservoir tank (not shown)). Tong system **500** also includes a first electric motor **523** for the power tong **520**, and a second electric motor **553** for the hydraulic power unit **550**. The second electric motor **553** may be smaller than the first electric motor **523**. In some embodiments, the second electric motor **553** may be about 1/10 of the size of the first electric motor **523**. Both the first electric motor **523** and the second electric motor **553** may be otherwise similar to onboard electric motor **453**. Hydraulic power unit **550** may supply hydraulic power to one or more hydraulic power consumers, such as the backup tong **510**, the lift actuators **530**, and the door actuators **540**. First electric motor **523** may supply torque and/or rotation to power tong **520**. Output of first electric motor **523** may supply power to drivetrain **525** (e.g., a gearbox and a rotor) for power tong **520**. In some embodiments, output of second electric motor **553** may supply power to pump **552** to store hydraulic power in accumulator **551** while one or more of the backup tong **510**, lift actuators **530**, and/or door actuators **540** are inactive. In some embodiments, the output of second electric motor **553** may supply power to pump **552** to directly drive one or more of the backup tong **510**, lift actuators **530**, and/or door actuators **540**. In some embodiments, while the second electric motor **553** and/or the pump **552** are inactive, the accumulator **551** may supply power to directly drive one or more of the backup tong **510**, lift actuators **530**, and/or door actuators **540**. For example, pressure switch **581** may shut off second electric motor **553** when a target pressure in accumulator **551** has been reached. In some embodiments, tong system **500** may not receive hydraulic power from an external source (e.g., a hydraulic power unit on the rig floor). Specifically, backup tong **510** may only receive hydraulic power from local hydraulic power unit **550**.

In some embodiments, first electric motor **523** may be selected to supply sufficient torque and rotation to power tong **520**, as illustrated by the work cycle graphs of FIGS. **2**-**3**. In some embodiments, second electric motor **553** may be selected to supply sufficient power to drive hydraulic power unit **550** between power tong work cycles. Consequently, first electric motor **523** and/or second electric motor **553** may be small enough to not pose excessive risks (e.g., heat, noise, fuel consumption) in the rig environment.

Tong system **500** of FIG. **5** may also include electronics **560**. The electronics **560** may include a charger **562**, a programmable logic controller **564**, a battery **566**, and an inverter **568**. Electronics **560** may be configured similar to electronics **460** and may function similar thereto. First electric motor **523** may be driven and/or controlled by electronics **560**. For example, the torque of first electric motor **523** may be proportional to the current coming from the inverter **568**. Likewise, the speed of first electric motor **523** may be in phase with the frequency of the current coming from the inverter **568**. First electric motor **523** may supply torque to power tong **520** in order to make-up to tubulars to a precise target torque while maintaining this torque for some time.

Second electric motor **553** may be controlled by electronics **560**. In some embodiments, programmable logic controller **564** may control power supply to the consumers. For example, the sources of hydraulic power may be the pump **552** (driven by the second electric motor **553**) and/or the accumulator **551**. At times during operations, each of backup tong **510**, lift actuators **530**, and door actuators **540** may be powered by one or more of the sources of hydraulic power. The programmable logic controller **564** may determine which power source supplies which consumer at any point in time during operations. For example, the programmable logic controller **564** may determine a target pressure for accumulator **551**. Pressure switch **581** may shut off second electric motor **553** when the target pressure in accumulator **551** has been reached.

An exemplary make-up cycle **600** is illustrated in FIG. **6**. The illustrated make-up cycle **600** is applicable to tong system **400**, and a similar make-up cycle could be envisioned for tong system **500**. Initially, in region **610**, hydraulic power is supplied to the door actuator **440** to open the tubular access door **145** and allow for stabbing-in of new tubular. Accumulator **451** and/or pump **452** may supply hydraulic power to door actuator **440**. Switchbox **480** may, therefore, be set to power hydraulic power unit **450** with onboard electric motor **453** during this initial region **610**. The amount of hydraulic power **615** supplied is relatively low, so the battery **466** may charge (positive current **625**) during region **610**. In region **620**, lift actuators **430** may vertically position the backup tong **410**. Accumulator **451** and/or pump **452** may supply hydraulic power to lift actuators **430**, and switchbox **480** may remain set to power hydraulic power unit **450** with onboard electric motor **453** during region **620**. The amount of hydraulic power **615** supplied is sufficiently high to cause battery **466** to discharge (negative current **625**). In region **630**, backup tong **410** may clamp the tubular. Accumulator **451** and/or pump **452** may supply hydraulic power to backup tong **410**, and switchbox **480** may remain set to power hydraulic power unit **450** with onboard electric motor **453** during region **630**. As backup tong **410** engages and securely clamps the tubular, the hydraulic power **615** increases, causing the battery **466** to cycle from charging to discharging (positive to negative current **625**). Clamping force **635** is initially constant during region **630**, increasing to the endpoint for backup tong **410** at the end of region **630**. In region **640**, door actuator **440** may close the tubular access door **145** as backup tong **410** continues to securely clamp the tubular. Accumulator **451** and/or pump **452** may supply hydraulic power to door actuators **440** and backup tong **410**, and switchbox **480** may remain set to power hydraulic power unit **450** with onboard electric motor **453** during region **640**. The clamping force **635** is essentially constant during region **640**. Throughout regions **610**-**640**, onboard electric motor **453** has zero torque **645** and rotation speed **655**.

The exemplary make-up cycle **600** continues from region **640** to region **650** wherein switchbox **480** switches the onboard electric motor **453** from supplying power to the hydraulic power unit **450** to the drivetrain **425** of power tong **420**. Hydraulic power **615** from onboard electric motor **453**, therefore, remains at zero in region **650** through the middle of region **680**. The relatively constant clamping force **635** of backup tong **410** may be maintained by the accumulator **451**. In some embodiments, a brace may be applied to hold the backup tong **410** in the clamped position, thereby maintaining the relatively constant clamping force **635** without hydraulic power from the accumulator **451** or pump **452**. In some embodiments, a valve may be closed to hold pressure in the cylinder(s) of backup tong **410**, thereby maintaining the relatively constant clamping force **635** without hydraulic power (pressure or flow) from the accumulator **451** or pump **452**.

In region **650**, onboard electric motor **453** initially drives drivetrain **425** with low torque **645** and low rotation speed **655** as tubular threading is engaged. Torque **645** may be increased as threading is confirmed. Current **625** may cause the battery **466** to go from charging to discharging as torque **645** increases. In region **660**, onboard electric motor **453** may operate drivetrain **425** in high gear to spin-in the tubular. The onboard electric motor **453** may initially have zero torque **645** and rotation speed **655** while shifting gears. Current **625** may initially charge battery **466** until higher torques **645** cause the battery to discharge. The spin-in of region **660** may continue at a relatively constant rotation speed **655** until a reference torque **645** is reached. In region **670**, onboard electric motor **453** may operate drivetrain **425** in low gear to make-up the connection to a target torque **645**. By shifting gears, the rotation speed **655** of onboard electric motor **453** in region **670** may be similar to that of region **660**. The ongoing clamping force **635**, rotation speed **655**, and increasing torque **645** causes the current **625** to be negative (battery **466** discharging) during much of region **670**.

The exemplary make-up cycle **600** concludes in regions **680** and **690**, as the threaded connection now couples the tubular to the tubular string. Power tong **420** is detached from the tubular early in region **680**, requiring a relatively small amount of torque **645** and rotation speed **655** from onboard electric motor **453**. Switchbox **480** then switches the onboard electric motor **453** to the hydraulic power unit **450**. The door actuators **440** may open the tubular access door **145** to release the tubular, drawing a relatively low amount of hydraulic power **615**. Battery **466** may charge with positive current **625** during region **680**. Lastly, in region **690**, backup tong **410** releases the tubular. As clamping force **635** ceases, current **625** may charge the battery **466** until it is fully charged.

In an embodiment a tong system includes a power tong for spinning tubulars; a first electric motor functionally connected to the power tong; a plurality of hydraulic power consumers including a backup tong for clamping a tubular string; a second electric motor functionally connected to the plurality of hydraulic power consumers; and electronics to drive the first electric motor and the second electric motor.

In one or more embodiments disclosed herein, the plurality of hydraulic power consumers comprises at least one of a lift actuator and a door actuator.

In one or more embodiments disclosed herein, the first electric motor couples to the power tong through a drivetrain having a low gear and a high gear.

In one or more embodiments disclosed herein, the tong system also includes a pump and an accumulator, wherein the second electric motor supplies hydraulic power with the pump.

In one or more embodiments disclosed herein, the tong system also includes a pressure switch to determine whether the pump or the accumulator supplies hydraulic power to at least one of the plurality of hydraulic power consumers.

In one or more embodiments disclosed herein, at least one of a torque and a speed of the first electric motor is controlled by the electronics.

In one or more embodiments disclosed herein, the electronics comprise a battery that is capable of charging while the first electric motor and the second electric motor together draw low current and discharging while the first electric motor and the second electric motor together draw high current.

In one or more embodiments disclosed herein, the electronics includes a charger; a programmable logic controller; a battery; and an inverter.

In an embodiment, a tong system includes a power tong for spinning tubulars; a plurality of hydraulic power consumers including a backup tong for clamping a tubular string; an onboard electric motor; and a switchbox providing at least two configurations of the tong system: in a first configuration, the onboard electric motor drives the power tong but does not supply hydraulic power to the plurality of hydraulic power consumers; and in a second configuration, the onboard electric motor does not drive the power tong but does supply hydraulic power to at least one of the plurality of hydraulic power consumers.

In one or more embodiments disclosed herein, the plurality of hydraulic power consumers comprises at least one of a lift actuator and a door actuator.

In one or more embodiments disclosed herein, in the first configuration, the onboard electric motor couples to the power tong through a drivetrain having a low gear and a high gear.

In one or more embodiments disclosed herein, the tong system also includes a pump and an accumulator, wherein, in the second configuration, the onboard electric motor supplies hydraulic power with the pump.

In one or more embodiments disclosed herein, in the first configuration, the accumulator supplies hydraulic power to at least one of the plurality of hydraulic power consumers.

In one or more embodiments disclosed herein, the tong system also includes electronics, wherein, in the first configuration, at least one of a torque and a speed of the onboard electric motor is controlled by the electronics.

In one or more embodiments disclosed herein, the electronics comprise a battery that is capable of charging while the onboard electric motor draws low current and discharging while the onboard electric motor draws high current.

In one or more embodiments disclosed herein, the electronics include a charger; a programmable logic controller; a battery; and an inverter.

In an embodiment, a tong system includes a backup tong for clamping a tubular string; an onboard electric motor; and an onboard hydraulic power unit coupled to the onboard electric motor to supply hydraulic power to the backup tong.

In one or more embodiments disclosed herein, the hydraulic power unit comprises a pump and an accumulator.

In one or more embodiments disclosed herein, the tong system also includes a pressure switch to determine whether the pump or the accumulator supplies hydraulic power to the backup tong.

In one or more embodiments disclosed herein, a volume of the hydraulic power unit is less than about 50 liters.

In an embodiment, a method of making-up tubulars includes arranging a tong system in a hydraulic power configuration; supplying hydraulic power to at least one of a plurality of hydraulic power consumers to position a tubular for make-up; arranging the tong system in a rotary drive configuration; supplying at least one of torque and rotation to a power tong; wherein an onboard electric motor of the tong system supplies the hydraulic power when the tong system is in the hydraulic power configuration, and the onboard electric motor supplies the at least one of torque and rotation when the tong system is in the rotary drive configuration.

In one or more embodiments disclosed herein, the onboard electric motor does not supply hydraulic power when the tong system is in the rotary drive configuration, and the onboard electric motor does not supply torque or rotation when the tong system is in the hydraulic power configuration.

In one or more embodiments disclosed herein, the plurality of hydraulic power consumers comprises a door actuator, and positioning the tubular for make-up includes opening a tubular access door with the door actuator.

In one or more embodiments disclosed herein, the plurality of hydraulic power consumers comprises a lift actuator and a backup tong, and positioning the tubular for make-up includes vertically positioning the backup tong with the lift actuator.

In one or more embodiments disclosed herein, the plurality of hydraulic power consumers comprises a backup tong, the method further comprising clamping a tubular string with the backup tong.

In one or more embodiments disclosed herein, the onboard electric motor supplies hydraulic power to the backup tong when the tong system is in the hydraulic power configuration, and an accumulator of the tong system supplies hydraulic power to the backup tong when the tong system is in the rotary drive configuration.

In one or more embodiments disclosed herein, the tong system comprises electronics, the method further comprising controlling at least one of a torque and a speed of the onboard electric motor with the electronics.

In one or more embodiments disclosed herein, the electronics comprises a battery, the method further comprising charging and discharging the battery in response to current drawn by the onboard electric motor.

In one or more embodiments disclosed herein, the supplying at least one of torque and rotation to the power tong comprises first spinning the tubular in high gear until a reference torque is reached, and then spinning the tubular in low gear to a target torque.

While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

The invention claimed is:

1. A tong system comprising:
- a power tong for rotating a first tubular;
- a plurality of hydraulic power consumers including a backup tong for clamping a second tubular;
- an onboard electric motor; and
- a switchbox providing at least two configurations of the tong system:
- in a first configuration, the onboard electric motor mechanically drives the power tong but does not supply hydraulic power to the plurality of hydraulic power consumers; and
- in a second configuration, the onboard electric motor does not mechanically drive the power tong but does supply hydraulic power to at least one of the plurality of hydraulic power consumers.

2. The tong system of claim **1**, wherein the plurality of hydraulic power consumers comprises at least one of a lift actuator and a door actuator.

3. The tong system of claim **1**, wherein, in the first configuration, the onboard electric motor couples to the power tong through a drivetrain having a low gear and a high gear.

4. The tong system of claim **1**, further comprising a pump and an accumulator, wherein, in the second configuration, the onboard electric motor supplies hydraulic power with the pump.

5. The tong system of claim **4**, wherein, in the first configuration, the accumulator supplies hydraulic power to at least one of the plurality of hydraulic power consumers.

6. The tong system of claim **1**, further comprising electronics, wherein, in the first configuration, at least one of a torque and a speed of the onboard electric motor is controlled by the electronics.

7. The tong system of claim **6**, wherein the electronics comprise a battery that is capable of charging while the onboard electric motor draws low current and discharging while the onboard electric motor draws high current.

8. The tong system of claim **6**, wherein the electronics comprise:
- a charger;
- a programmable logic controller;
- a battery; and
- an inverter.

9. A tong system comprising:
- a power tong for rotating a first tubular;
- a backup tong for clamping a second tubular;
- an onboard electric motor; and
- a switchbox adapted to switch between at least two configurations of the tong system:
- in a first configuration, the onboard electric motor is mechanically coupled to a drivetrain of the power tong and is mechanically decoupled from an onboard hydraulic power unit, and
- in a second configuration, the onboard electric motor is mechanically coupled to the onboard hydraulic power unit and is mechanically decoupled from the drivetrain of the power tong.

10. The tong system of claim **9**, wherein the hydraulic power unit comprises a pump and an accumulator.

11. The tong system of claim **10**, further comprising a pressure switch to determine whether the pump or the accumulator supplies hydraulic power to the backup tong.

12. The tong system of claim **11**, wherein the pressure switch is configured to shut off the onboard electric motor when a predetermined pressure is reached in the accumulator.

13. The tong system of claim **9**, wherein a volume of the hydraulic power unit is less than about 50 liters.

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